TESTIMONY OF

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BEFORE THE

SUBCOMMITTEE ON ENERGY AND RESOURCES
GOVERNMENT REFORM COMMITTEE

U.S. HOUSE OF REPRESENTATIVES

ON THE SUBJECT OF
"REBALANCING THE CARBON CYCLE"

SEPTEMBER 27, 2006

Introduction

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear before you today and report on the Federal Carbon Cycle Research Program. This research is an important element of the Climate Change Science Program (CCSP), and is coordinated by one of its working groups, the Carbon Cycle Interagency Working Group. I am co-chair of that working group; Mr Ed Sheffner of the National Aeronautics and Space Administration (NASA) is the other co-chair, and I gratefully acknowledge his significant contributions to this testimony.

My testimony focuses on scientific scope of the Inter-Agency program implementing the Carbon Cycle research element of the CCSP Strategic Plan. The U.S. Carbon Cycle Research Program is embedded in the U.S. Climate Change Research Program. It implements research related to an important CCSP goal, "to improve quantification of the forces bringing about changes in the Earth's climate and related systems." Atmospheric CO_2 is considered a primary forcing agent of future climate; accordingly, CO_2 and carbon cycle research is a high priority of the CCSP.

We know from long-term measurements that the concentration of atmospheric CO_2 is increasing, currently at the rate of about 1.8 ppm per year. Much of the increase is attributed to CO_2 emissions from fossil fuel combustion, as reported by members of the Science Panel at this hearing. It is also recognized that not all the CO_2 emissions remain in the atmosphere because there is a large net exchange of CO_2 from the atmosphere into the ocean and land. This net exchange of carbon from the atmosphere into the ocean and land on a global scale involves a large number of processes and properties, where some are known qualitatively. An aggressive, multi- and inter-agency research program, the

U.S. Carbon Cycle Carbon Program, is employed by the U.S. Government to better understand quantities and uncertainties of fluxes, properties and processes of numerous components of the carbon cycle. Much of the research focuses on quantifying rates and magnitudes of CO_2 exchanges between the atmosphere and ocean and the atmosphere and land, and on improving estimates of terrestrial and oceanic carbon sources and sinks. Carbon cycle research programs sponsored by Agencies of this Program seek to understand the processes that currently remove more than half of fossil fuel emissions from the atmosphere before they can affect the climate. It is crucial to know whether these processes will continue to operate and whether there is anything that we can do to increase their efficiency. Without reliable practical knowledge of the sinks, we can't hope to project the impact of future CO_2 emissions. This basic research is needed to address one of the most significant sources of uncertainty in projections of future climate. Results are providing knowledge of contemporary changes in carbon sinks which, when combined with other information, provides the basis for projecting future atmospheric CO_2 change and its influence on climate. The Program is also developing tools for measuring and prognostic modeling of changes in carbon sinks, and it provides the scientific foundation to support future greenhouse gas management strategies.

The U.S. Government Carbon Cycle Program for implementing research is described in chapter seven of the CCSP Strategic Plan (http://www.climatescience.gov/Library/stratplan2003/) . Key scientific questions that guide the Government's implementation of an integrated Carbon Cycle Program are:

- "What are the magnitudes and distributions of North American carbon sources and sinks on seasonal to centennial time scales, and what are the processes controlling their dynamics?"

- "What are the magnitudes and distributions of ocean carbon sources and sinks on seasonal to centennial time scales, and what are the processes controlling their dynamics?"
- "What are the effects on carbon sources and sinks of past, present, and future land-use change and resource management practices at local, regional, and global scales?"
- "How do global terrestrial, oceanic, and atmospheric carbon sources and sinks change on seasonal to centennial timescales, and how can this knowledge be integrated to quantify and explain annual global carbon budgets?"
- "What will be the future atmospheric concentrations of carbon dioxide, methane, and other carbon-containing greenhouse gases, and how will terrestrial and marine carbon sources and sinks change in the future?"
- "How will the Earth system, and its different components, respond to various options for managing carbon in the environment, and what scientific information is needed for evaluating these options?"

These questions have been carefully defined, extensively reviewed and vetted with the carbon cycle science community, and discussed with stakeholders. They are key reference points used by the Carbon Cycle Interagency Working Group (CCIWG) in carrying out carbon cycle science research in the United States.

The CCIWG is one of nine natural sciences and cross-cutting working groups that coordinate and integrate CCSP's research elements within and across agencies. The CCIWG has responsibility for coordinating solicitations and reviews of research proposals (when appropriate); for implementing targeted research; for providing an interface with the scientific community; for updating assessments of research needs and priorities; and for identifying new Inter-Agency research activities. The CCIWG provides up-to-date information to both government and non-government users, it annually communicates results and accomplishments in the "Our Changing Planet" report to Congress, and it is sponsoring the development of a Synthesis and Assessment Product (SAP, see below).

The Interagency Working Group is comprised of 10 participating federal agencies and departments, which support and execute U.S. carbon cycle science research:

- Department of Agriculture (USDA):
  - Agricultural Research Service (ARS)
  - Cooperative State Research, Education and Extension Service (CSREES)
  - Forest Service (FS)
  - Natural Resources Conservation Service (NRCS)
- Department of Commerce (DOC):
  - National Oceanic and Atmospheric Administration (NOAA)
- Department of Energy (DOE): Climate Change Research Division (CCRD)
- Environmental Protection Agency (EPA)
- Department of Interior (DOI): United States Geological Survey (USGS)
- National Aeronautics and Space Administration (NASA): Earth Science Division (ESD)
- National Science Foundation (NSF)

The CCIWG is currently co-chaired by members from the DOE and NASA, and has proved to be a very effective means for achieving management and coordination goals. Selected activities of the CCIWG include:

- Coordinating carbon cycle science research across multiple agencies, including enhancement of global and national carbon observational systems and networks;
- Implementing the North American Carbon Program (NACP);
- Implementing Ocean Carbon and Climate Change (OCCC) Program;
- Completing the Synthesis and Assessment Product 2.2 of the CCSP;
- Promoting the development of coupled carbon cycle-climate and -Earth system models;
- Providing scientific information for carbon sequestration; and
- Promoting joint research with Canada and Mexico on the North American carbon cycle.

Coordination of carbon cycle science: The CCIWG coordinates research among its participating agencies to leverage efforts and avoid duplication, while enhancing overall scientific findings and products. Coordination builds on unique agency capabilities and

resources: for example, the AmeriFlux observational network of CO_2 fluxes between atmosphere and terrestrial biosphere led by DOE; NOAA's GLOBALVIEW CO_2 monitoring network (including airborne platforms and instrumentation); and NASA's capabilities in land, ocean and atmospheric observations from space. These observations are linked with models and other tools to gain a more complete understanding of changes in the carbon cycle, including improved quantification of terrestrial and oceanic carbon sources and sinks. Combined with research sponsored by the CCIWG participants on carbon cycle processes and fluxes (that include joint solicitations of research proposals by two or more participating agencies), the Carbon Cycle Science Program is leading to new clarity and insights into the carbon cycle at the local and regional levels. This new knowledge also enhances the ability to "scale up" carbon source and sink information to the Continental U.S. and North America, and provides foundations for global carbon cycle analysis.

North American Carbon Program (NACP): NACP is a priority research Program under the CCIWG which addresses key scientific questions noted above. The NACP goals are to quantify the magnitudes and distributions of carbon sources and sinks for North America and adjacent oceans; to understand the processes controlling source and sink dynamics; and to produce consistent analyses of North America's carbon budget that explain regional and sectoral values and year-to-year variability. The NACP is committed to understanding and quantifying the uncertainties related to the buildup of carbon dioxide, methane, and carbon monoxide in the atmosphere. Outcomes of the research are also expected to quantify more precisely parameters such as the fraction of fossil fuel carbon that is taken up by North America's ecosystems and adjacent oceans.

Ocean Carbon and Climate Change (OCCC) Program: The OCCC Program, another priority effort being implemented by the CCIWG, also addresses key scientific questions of carbon cycle research. OCCC goals are aimed at determining how much atmospheric carbon dioxide is being taken up by the ocean at the present time and how climate change will affect the future behavior of the oceanic carbon sink. The NACP and OCCC Program are synergistic, converging in addressing carbon dynamics in the coastal oceans adjacent to North America and at its land-sea margins, where changes in the terrestrial system greatly influence carbon processes in the coastal ocean. Coordinated NACP-OCCC research also quantifies carbon properties of coastal zones that influence atmospheric CO_2 concentration and trends over the continent.

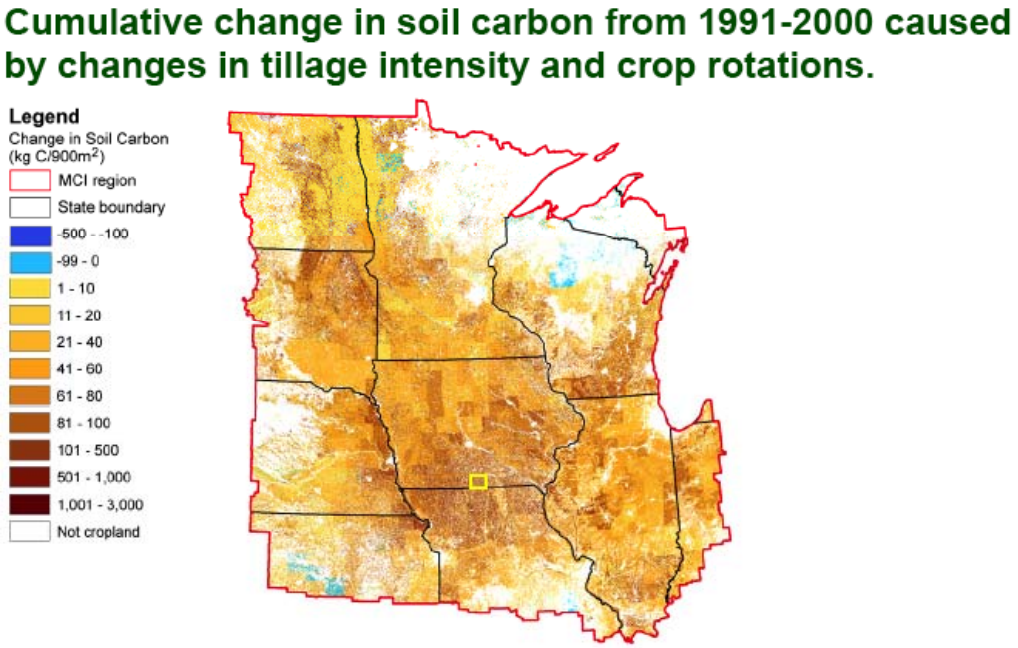
Synthesis and Assessment Product 2.2: The CCIWG is sponsoring the development of the Synthesis and Assessment Product (SAP) 2.2 of the CCSP. That assessment, "The First State of the Carbon Cycle Report (SOCCR): The North American Carbon Budget and Implications for the Global Carbon Cycle," is available for public review, and is on schedule for final release in March 2007. SAP 2.2 will provide an initial estimate of the state-of-the-knowledge of the North American carbon budget in a format useful to decision makers, and it will provide the best currently available scientific information on carbon cycle properties in format and language useful for those making decisions regarding carbon management and policy. Every stage of the report, including the prospectus, selection of authors, and review of the draft, has been publicly vetted, including responses to public comments. The process for SAP 2.2 has been open and very transparent, and it has fostered important interactions with stakeholder communities—i.e., environmental, industry, and public interest organizations—and with

individuals who may be concerned or affected by findings of the assessment. The range of stakeholder interactions has enhanced the value of the assessment for a broad spectrum of users, ensuring transparency of both process and product and relevance of the report to decision makers. Throughout the process, valuable stakeholder input has been obtained through workshops where scientists interact with representatives of stakeholder communities; a final workshop, which will include a review of the draft report, is scheduled for October 10, 2006.

Modeling and Integration: Observations of carbon reservoirs, exchange, and transport from NACP and OCCC are currently being evaluated and assimilated in coupled terrestrial-ocean-atmospheric and Earth System models. These models describe, simulate, and evaluate the spatial, seasonal, and inter-annual variations in carbon cycling, highlighting effects of atmospheric and climate variations. In addition, regional and global analyses of terrestrial and oceanic carbon sources and sinks are derived from remotely-sensed data. Observations of atmospheric CO_2 concentrations are assimilated with other emissions and flux data, and with the aid of mesoscale transport and global circulation models, these integrated approaches also identify locations of carbon sources and sinks. Integration of carbon cycle and climate system knowledge is implemented through joint activities of CCSP research elements such as Carbon Cycle, Climate Variability and Change, and Water Cycle research elements. Coordination of CCIWG research with these research elements supports coupled carbon cycle-climate modeling, including the use of high performance supercomputing resources to develop and run Earth system models.

Carbon Sequestration: The carbon dioxide concentration in the atmosphere can be influenced by reducing emissions of carbon compounds like carbon dioxide and methane, by increasing the amount of carbon removed from the atmosphere through natural terrestrial and oceanic uptake mechanisms, and by specific carbon management approaches. In the near term, carbon sequestration may help reduce the rate of increase in the concentration of greenhouse gases in the atmosphere and, over longer terms, carbon sequestration is expected to contribute to a suite of carbon management strategies. The CCIWG is already using knowledge from its NACP and OCCC Program investigations to address the key carbon management questions noted above. One example illustrates research related to the Mid-Continent Intensive of the NACP, where a provisional soil carbon sequestration map has been produced from a project awarded by the joint "Carbon Cycle Science" solicitation in 2004 (Fig 1). In another example, USDA operates the Greenhouse Gas Reduction Program through a Agricultural Carbon Enhancement network (GRACEnet) at 30 locations around the country to measure and predict carbon sequestration and greenhouse gas emissions across a range of agricultural systems, soils and climate zones. There are a number of other studies, like DOE's "Carbon Sequestration in Terrestrial Ecosystems (CSiTE) project, use knowledge of "natural" carbon cycle processes gained through earlier research to enhance terrestrial carbon sequestration. Mr. Eule's testimony this afternoon provides additional examples of carbon sequestration activities of the Climate Change Technology Program (CCTP).

Fig 1: T. West, ORNL, Information on carbon storage and emissions from soil is essential to understand the potential of agricultural systems to sequester carbon.



Research with Canada and Mexico on the North American carbon cycle:

Joint research is being planned as a part of the Administration's Climate Change Bilateral Agreements with Canada and Mexico. The United States, Canada, and Mexico are engaged in planning coordinated North American carbon cycle research at the full continental scale. Representatives of governments and scientific communities of the respective countries have agreed to work together, and further coordination as well as scientific meetings are planned for early in 2007. Meeting participants will develop scope, scientific collaborations, and Inter-governmental interactions for a joint Carbon Program of North America.

Resources: Total federal investment in carbon cycle science is $118M for FY 06. The table below shows the budget breakdown by agency of the CCSP Carbon Cycle Program's scientific research.

U.S. Carbon Cycle Research Budget Fiscal Year 2006	
(Discretionary Budget Authority)	
Agency	**$Millions**
USDA	16.4
DOC/NOAA	16.4
DOE	16.6
DOI/USGS	4.4
NASA	40.7
NSF	23.2
SI	0.3
Total	**118.0**

Budget information is extracted from Tables 4 and 5, pages 7 and 8 of FY2006 Budget Tables, "Our Changing Planet. The U.S. Climate Change Science Program for Fiscal Year 2006. A Report by the Climate Change Science Program and The Subcommittee on Global Change Research. A Supplement to the President's Fiscal Year 2006 Budget" (http://www.usgcrp.gov/usgcrp/Library/ocp2006/default.htm)

Summary: Changes in the carbon reservoirs and processes on land and in oceans are currently the leading sources of uncertainty in the projection of climate change in the 21st century. About half of the CO_2 emitted to the atmosphere by fossil fuel sources is taken up by a combination of land and ocean sinks; and inter-annual variability in carbon exchange within the atmosphere is dominated by terrestrial ecosystems. Atmospheric increase of CO_2 is estimated to contribute 60%-70% of the calculated greenhouse gas forcing of the climate system. Future forcing of climate will depend significantly on the rate of natural and anthropogenic CO_2 and CH_4 increases in the atmosphere, which in turn are modulated by strength and longevity of terrestrial and oceanic sources and sinks. These properties of the carbon cycle have considerable uncertainty, which are being addressed as a priority of the U.S. Carbon Cycle Research Program.